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Assessing the Scientific Literacy of Prospective Biology Teachers

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Abstract: Scientific literacy is one of the goals of science education so that students can use scientific principles to address science-related problems. A person who possesses scientific literacy was able to recognize, analyze, and design scientific research as well as interpret data using scientific evidence. Students that are scientifically literate can approach challenges by using a scientific approach. Nevertheless, not all of these skills are possessed by students, particularly those who are freshmen in college. The purpose of this study was to determine the scientific literacy skills of prospective biology teachers using the scientific method in the learning process. This research is pre-experimental with the one group pretest – posttest design, respondents was 31 new student of biology education in first semester. Worksheets based on the scientific method are used in the research instrument. Data analysis using the SPSS 25.0 program, paired t test statistical analysis was used for data analysis. The research findings can be concluded that met a significance threshold of 0.000 (p value 0.05), indicating that there was a difference between the typical student scores before and after the scientific method was used.

Keywords: Biodiversity; Constructivist learning; Creative problem solving; Creative thinking; Prospective teachers

Introduction

In an effort to produce human resources that are strong in all areas, including curriculum development, the Indonesian government has been working to improve its educational system over time. The present curriculum has been modified to reflect the evolution of the current situation and conditions, and scientific literacy, also known as scientific literacy, is currently being promoted in the educational process at all levels. Explained by She et al. (2019), Scientific literacy is the knowledge and understanding of science concepts and scientific processes necessary for personal decision-making, participation in society and culture, and economic productivity and changes brought about by human activity. It is the ability to identify questions and draw conclusions based on evidence or scientific data about nature. Students will find it easier to create questions, draw conclusions based on facts, and solve real-world issues both now and in the future if they have a solid understanding of scientific literacy (Anderson et al., 2020). The main objective is to evaluate students' literacy skills in reading, math, and science. One of the crucial skills that all students should possess is scientific literacy because it can help students change their perspectives, develop their critical and creative thinking skills, solve problems, and make decisions using a variety of factors that they have learned from various experiences and sources. Students can also apply it using the knowledge they already possess, but it must be supported by facts and proof (Madani, 2019).

Scientific literacy levels are low, which is not surprising given that process-based learning is typically less stressed in educational settings. Some conclusions from research on pupils' low levels of scientific literacy include the following: Indonesian students have poor levels of scientific literacy, and the educational system is not optimal for improving scientific literacy (Nabilah et al., 2022). Queiruga-Dios et al. (2020), found that the fundamental reason of inadequate scientific literacy is a lack of activities that assist pupils improve their skills in the classroom, based on his observations at a high school

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in the city of Bandung. Due to school instruction's propensity to concentrate on topics that are more abstract and unrelated to contemporary problems, few children still demonstrate a great interest in learning science (Milner, 2021).

The teacher often gives examples to students about the material they are learning and relates it to how useful it will be in daily life (Iivari et al., 2020). According to Jufrida et al. (2019), students' lack of scientific literacy is a reflection of their inexperience with solving science-related problems, their lack of training in doing so, and the fact that they still learn mostly through memorization of the teacher's lectures. One of the reasons why students' scientific literacy skills are low, according to Nainggolan et al. (2021), is because the learning process does not result in scientific procedures that would help the development of scientific literacy skills. Budiarti et al. (2021), cite additional factors that contribute to the low ability of scientific literacy as a result of the inadequate infrastructure and supporting facilities for scientific literacy-based learning.

In order to determine if students are knowledgeable about the science topics they have acquired, it is crucial to evaluate students' scientific literacy during the learning process. As everyone must possess scientific literacy, which includes understanding of science, ability to use science in processes, and attitudes toward science. It is your responsibility as a teacher to prepare your students so they are knowledgeable about problems and capable of solving them scientifically. Hence, to ensure that scientific teachings at school can subsequently be achieved in accordance with the learning objectives, prospective biology teacher students need to be prepared from the start of college by integrating learning approaches in the courses taught every semester. Rapanta et al. (2020), assert that a teacher must first have a solid understanding of those traits in order to properly explain science's aspects to pupils through a range of teaching strategies or approaches.

In addition a teacher in any subject area must be proficient in their chosen subject area as well as teaching, communication, assessment, attitude, and personal value traits (Omar et al., 2020). The study of biology, teachers need to have a comprehensive understanding of the characteristics of science and be able to communicate this understanding effectively to students through various learning strategies or approaches. For information, there are 31 new students in biology education at the Hamzanwadi University FMIPA for the 2022-2023 academic year with a background in different majors, namely Natural Sciences 64.52% and Non-Natural Sciences 35.48%. Based on these data, a question arises in the authors, do they already have scientific literacy even though they have studied biology at school? Through this general biology course, the authors try to explore their abilities by giving initial tests related to scientific literacy through the scientific method because this scientific method is the basic method in teaching the science process. As stated by Pellas et al. (2021), from the results of observing learning for their students that Due to the learning process only guiding students to experiment by following existing procedures, students have not been able to formulate problems, compile hypotheses, collect data, or analyze experimental data, preventing the development of their scientific learning abilities to their full potential.

Method

This type of research is pre-experimental with the One Group Pretest – Posttest Design (Creswell et al., 2018), because the number of classes of prospective biology teachers just one group. Respondents were 31 student in first semester in the biology education study program, Hamzanwadi University FMIPA. Worksheets with indicators for the scientific method are used to collect data, and they include: problems; formulating problems; data collection; hypotheses; testing hypotheses; and conclusions.

Students had previously taken an initial test (pretest) on plant growth and development, followed by an experiment to demonstrate it, before taking a second test (posttest) with the same questions as the pretest. Descriptive statistics were used to characterize the research findings. To ascertain whether the treatment given to the research subjects had an impact on the results, data analysis using the paired T test statistical analysis was performed using the SPSS 25.0 application. Using the following calculation formula, the gain score was calculated and divided into high, medium, and low categories (Savinainen et al., 2002) with the following calculation equation:

$$g = \frac{(s\ post - s\ pre)}{(s\ max - s\ pre)} \quad (1)$$

Note: g = Increasing score, S_{post} = Post test Score, S_{pre} = Pre test score, and S_{max} = Maximum score.

Based on the results of the obtained score, it is then categorized into the following criteria:

Table 1. Grade Interval for Categorization

No	Score	Category
1	$g < 0.3$	Low
2	$0.3 \leq g \leq 0.7$	Average
3	$g > 0.7$	High

Result and Discussion

The essence of natural science includes a process of scientific inquiry as well as the mastery of a body of

information in the form of facts, concepts, or principles (Willingham, 2021). Science may assist people in thinking critically, analytically, creatively, and logically in order to solve problems and come to logical, methodical judgments. And on the basis of this, it is essential to develop students' scientific literacy skills throughout the educational process because they form the cornerstone of student cognitive progress. To learn about scientific literacy, one must take into account three different things: science as a body of knowledge, science as a way of thinking, and science as a method of conducting research.

Organization for Economic Cooperation and Development (OECD) member nations administer the Program for International Student Assessment (PISA) to measure students' proficiency in science (PISA). PISA develops three aspects of scientific literacy: Scientific Concepts (Scientific Literacy); Scientific Processes include: Recognizing scientific questions, identifying evidence, Drawing and evaluating conclusions, Communicating conclusions, and Demonstrating understanding; Scientific Context and Areas of Application.

The Republic of Indonesia's Ministry of National Education has developed a new instructional style called the scientific approach in an effort to help students become more scientifically literate. The goal of scientific learning in the classroom is to develop students' skills in observation of common natural events and problem-solving that is realistic, logical, critical, and creative. Hence, lecturers should have more information to train students in science as a prospective teacher, such as designing learning tools based on the scientific method.

Lecturers must offer students learning resources that are grounded in scientific literacy and that can help students develop their cognitive, emotional, and psychomotor skills (Burhaein et al., 2021). According to the researchers themselves, this is a fundamental scientific method that is used to familiarize students with thinking and carrying out activities/experiments in a simple and scientific way. The following describes the results of the scientific literacy of prospective biology teacher students using this method. The scientific method was also developed as a result of PISA; one of its byproducts is the scientific process, which comprises recognizing scientific issues, locating evidence, drawing and assessing conclusions, expressing conclusions, and demonstrating comprehension. There are four types of scientific literacy: science as a body of knowledge, science as a method of inquiry, science as a way of thinking, and science as the interplay of science, environment, technology, and society (A'yun et al., 2020).

Before introducing the content, a worksheet with indicators for the scientific method is supplied to gauge the students' starting knowledge. On the basis of these explanations of the scientific method, students conducted experiments and proofs, and during these experiments, a number of students failed. This was due to a number of reasons, including the weather, the state of the seeds, and the media utilized. Due to this failure, students were urged to repeat the experiment in order for them to fully comprehend the significance of the scientific process that they had applied themselves. The information on using the scientific method is about the reasons why plants wilt because pupils nearby frequently experience these occurrences (Figure 1).

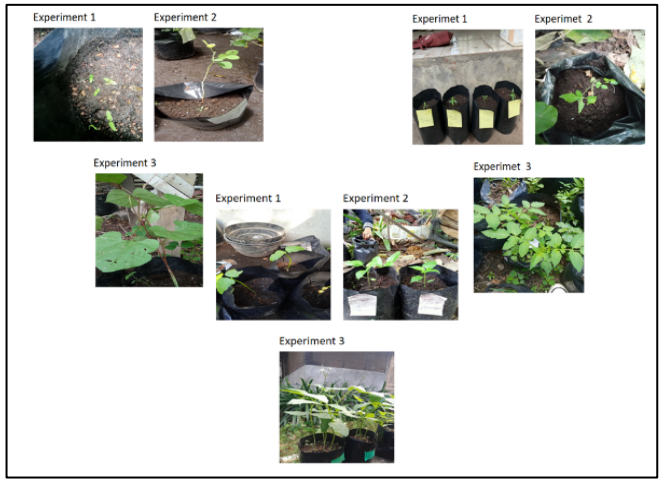

Figure 1. Examples of experimental findings from students who used the scientific method

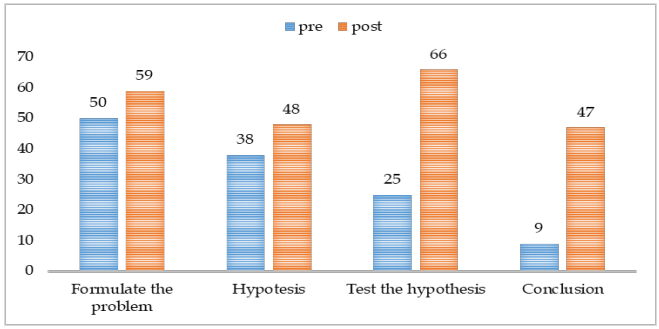

Figure 2. Results of the pre-test and post-test on new students' knowledge of the scientific process prospective biology teachers

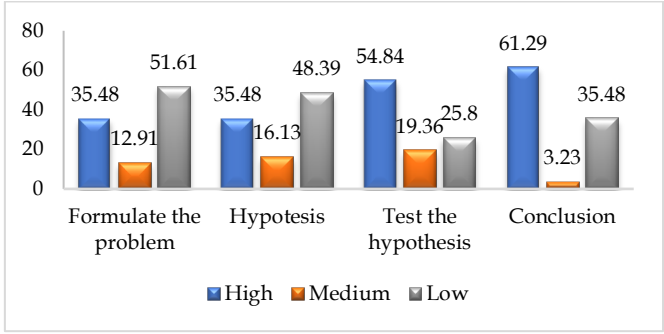

Figure 3. The acquisition percentages for new biology teacher candidates in the high, medium, and low categories for scientific method abilities

The depth of the students' knowledge after the experiment was completed was then determined by a post-test. The following is a graphic representation of the scores obtained using the scientific technique (Figure 2). The next step is to categorize the scores obtained from the pretest and posttest results into low, medium, and high categories (Figure 3).

With the aid of the SPSS 25.0 application and the statistical test findings, a descriptive statistical analysis (paired t-test) was conducted to determine whether the scientific method has any impact or not.

Descriptive Statistics

According to table 2, the pre-test average is 14.35, and the post-test average is 45.32. This indicates that the average value before the test was 30.97 less than the average value after the test. Based on the acquisition of the average value, it shows that scientific learning can raise the average student score. Table 3 shows the average pre-test and post-test values to determine whether there was a statistically significant difference between them.

Table 2. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Test	14.3548	31	15.20646	2.7311
	Post Test	45.3226	31	28.25289	5.0743

Table 3. Significant Test Results of Learning the Scientific

	Paired Samples Test							
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	SD	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pre- Post Test	-30.96	36.57	6.56	-44.38	-17.55	-4.72	30	.000

Based on Table 3, the t count is -4.715 and H_0 is rejected or the two populations' means are not equal because of the probability or significance level of 0.000 (p value 0.05), The average pre-test and post-test values are significantly different. It is evident that there are variations between students' average test scores before and after using the scientific method.

Understanding how people think and using science to identify and solve common social issues in society are two benefits of scientific literacy. Muhariyansah et al. (2021), says that when students are able to understand and apply basic principles of science to everyday life, society, and technology, these students fall into the multidimensional category. Scientific literacy and causal thinking are associated at the same time, and each foretells the other in coming years. According to Shavlik et al. (2022), teaching scientific literacy can include a variety of constructivist learning approaches, including inquiry, problem-based learning, project-based learning, and STEM/STEAM, with one of the goals being to develop students' social and personal problem-solving abilities.

With an average implementation rate of 86%, the implementation of scientific literacy learning using a scientific inquiry approach is rated as very good for each instructor (Basam et al., 2017). Ni'mah (2019) and Wen et al. (2020) used an inquiry-based learning paradigm, either independent or guided inquiry, which has the ability to raise students' science iterations, support students' science success levels, and develop students' literacy skills. If students participate in investigative activities like inquiry learning, which entail testing hypotheses, then increasing scientific literacy will be improved (Herlanti et al., 2019). According to Fatmawati et al. (2020), including inquiry into the learning process can help students develop their scientific thinking and attitudes. Project Based Learning implementation can enhance scientific literacy and process abilities (Tias et al., 2018).

The following aspects can be taken into consideration while using school as a venue to habitually practice scientific literacy: Use the scientific method when solving issues by 1) comprehending the fundamental ideas and principles of science and integrating them with math and technology, and 2) doing so. According to Oliver et al. (2020), schools can encourage students' interests and enjoyment in order to promote scientific literacy as well as a good attitude, awareness, and responsibility towards the environment. Sultan et al. (2021) as long as they get more knowledge of scientific literacy and the essence of science, instructors may exhibit a sufficient awareness of the connection between science, technology, and society.

Conclusion

Understanding the nature of science, including science as a body of information or output, science as a technique of inquiry through the scientific method, and science as the development of personal scientific attitudes, is crucial to fostering students' scientific literacy. It is intended that people who comprehend science's fundamental significance will be scientifically literate and use this information to make decisions that are thoughtful, original, rational, practical, and methodical. Because scientific literacy teaches ways of thinking and acting by engaging higher-order thinking

skills, it is a combination of scientific ideas and concepts that may be used to many cross-disciplines. Because classroom learning is still primarily rote learning, students' low scientific literacy has an impact on their higher-order thinking abilities. This is closely related to the learning process in the classroom, which does not give them opportunities to conduct investigations, investigations, or experiments. Hence, new biology teacher candidates have already been trained in higher order thinking abilities and are accustomed to using them when they face natural phenomena that are present in their community's social life. The results of the learning that has been carried out on prospective biology teachers at Hamzanwadi University, there was a significant impact on scientific literacy skills using the scientific method with a significance of 0.000 (p value 0.05), which indicates that there was a difference in the average student score before and after the application of scientific method learning.

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Author Contributions
The role of Baiq Fatmawati in this study was to compile the background and find problems that occur, design research methods, analyze, process and present data, discuss research results and findings. Meanwhile, the role of Husnul Khotimah is to process data.

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Because this research is independent, there is no conflict of interest to anyone.

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